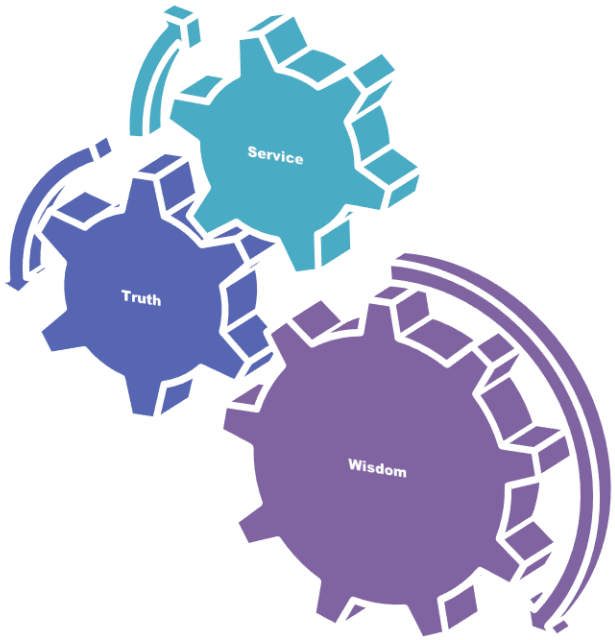

بسم الله الرحمن الرحيم

Motto Vision; The Dream/Tomorrow

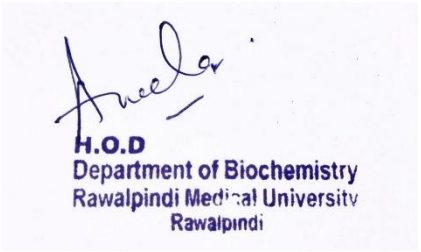


- To impart evidence based research oriented medical education
- To provide best possible patient care
- To inculcate the values of mutual respect and ethical practice of medicine

Foundation Module

1st Year MBBS(LGIS)

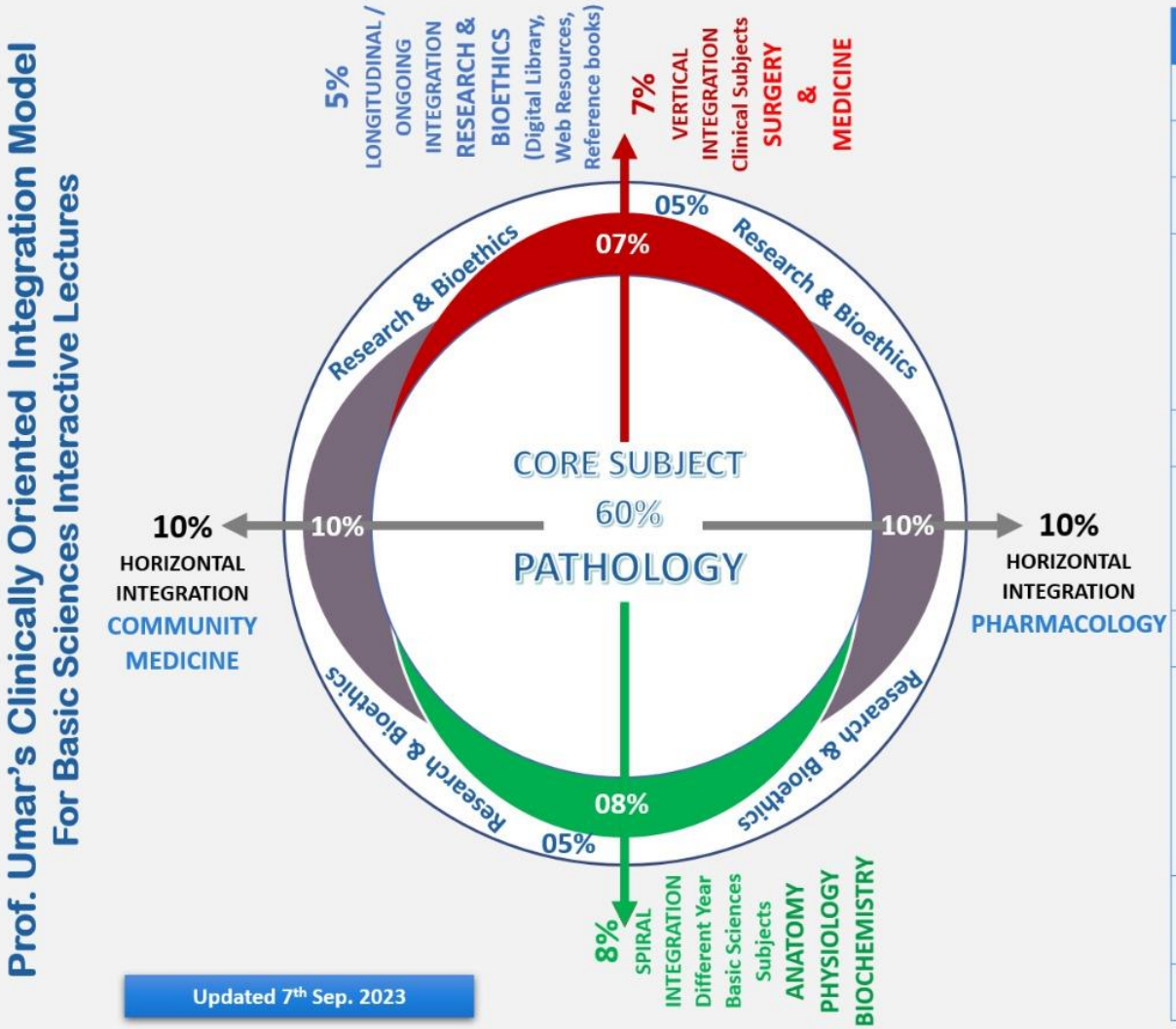
Physicochemical Properties-2



Presenter: Dr Nayab Ramzan
Deptt of Biochemistry
RMU

Date: 07-02-25

Professor Umar Model of Integrated Lecture



Model 3rd Year Pathology LGIS (≈30 slides)	
Core Subject – 60% (≈ 18-20 slides)	
Pathology (≈ 18-20 slides)	
Horizontal Integration – 20% (≈ 5-6 slides)	
Same Year Subjects	• Pharmacology (10%) (≈ 2-3 slides) • Community Medicine (10%) (≈ 2-3 slides)
Vertical Integration – 07% (≈ 2-3 slides)	
Clinical Subjects	• Medicine (3-5%) (≈ 1-2 slides) • Surgery (3-5%) (≈ 1-2 slides)
Spiral Integration – 08% (≈ 2-3 slides)	
Different Year Basic Sciences Subjects	• Anatomy (1-3%) (≈ 1-2 slides) • Physiology (1-3%) (≈ 1-2 slides) • Biochemistry (1-3%) (≈ 1-2 slides)
Longitudinal / Ongoing Integration – 05% (≈ 1-2 slides)	
Research & Bioethics (≈ 1-2 slides)	

Learning Objectives

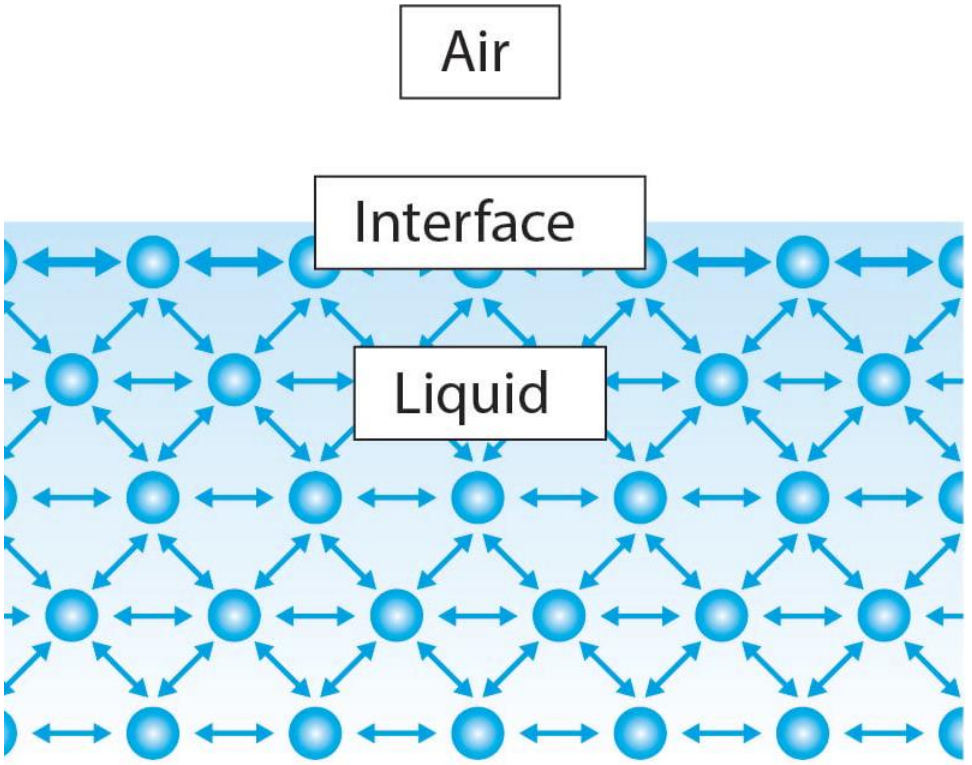
At the end of the session, students will be able to

1. Define phenomenon of Surface Tension & Emulsification, Explain their Biochemical Applications and methods to measure Surface Tension.
2. Define and Explain Donnan's Equilibrium.
3. Correlate physicochemical properties of cell with clinical conditions
4. Practice the principles of bioethics & apply strategic use of A.I in the related clinical aspects.
5. Read relevant research articles related to the Core Knowledge.

Surface Tension

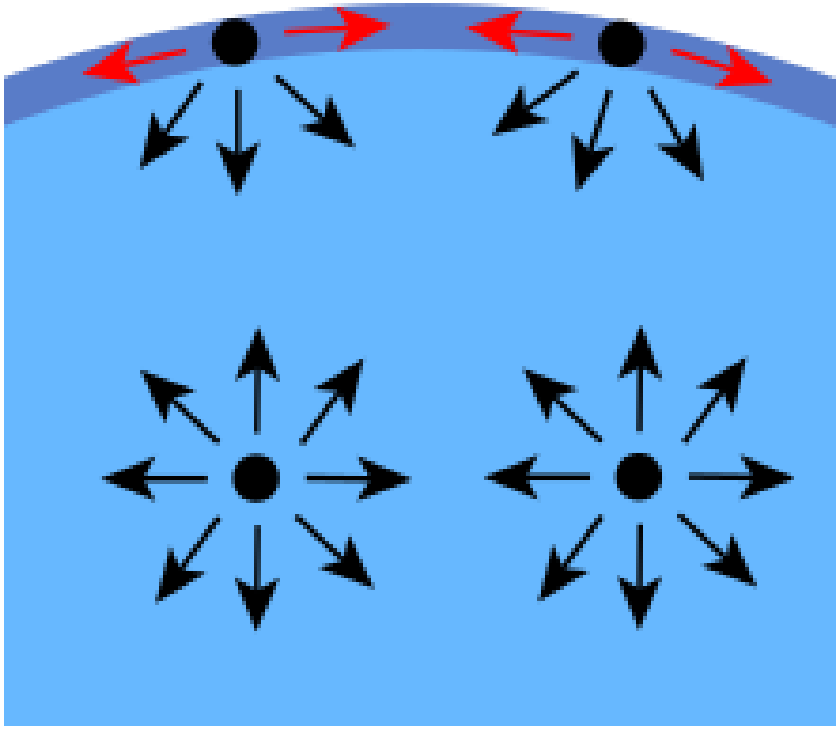
Defined as

The force acting **Perpendicularly Inwards** on the **Surface Layer** of a liquid to **Pull** it's surface molecules towards the **Interior** of the fluid.



Surface Tension

- A molecule in the Interior of a liquid is attracted by other molecules in all directions.



- In contrast, a molecule on the surface is attracted only downwards and sideways and not upwards so they are **not free to move**

- Due to this the surface layer behaves like a stretched membrane or film.

- Surface Tension is the **force with which the molecules on the surface are held together**.

Surface Tension

- Surface tension is measured in **ergs/cm2** or **dynes/cm**.

- Surface tension is expressed in **dynes acting perpendicularly to 1 cm line on a liquid surface.**

- The surface tension in **dynes/cm** of
  - Mercury= 465
  - Water = 72.8
  - Glycerol = 65.2
  - Ether = 21.7

- **Soaps**, **Detergents** and **Bile Salts Reduce** the surface tension
- **Salts** like **NaCl Increase** it

Measurement of Surface Tension

➢ Drop Method

- To find out the **Surface Tension of a Liquid Relative to that of Water** the number of drops produced by a given volume of two liquids is found out.
- The apparatus used for these determinations is called **stalagmometer**.
- Suppose we want to compare the surface tension of some **Oil** with that of **Water**.
- **Water** is first sucked up the tube and the drops counted as it falls from A - B, then in 2nd round it is filled with **Oil** and the number of drops formed by the same volume are counted, the **Relative Surface Tension** is then given by.

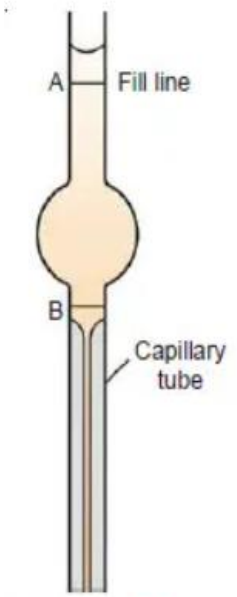


Figure 1
A stalagmometer.

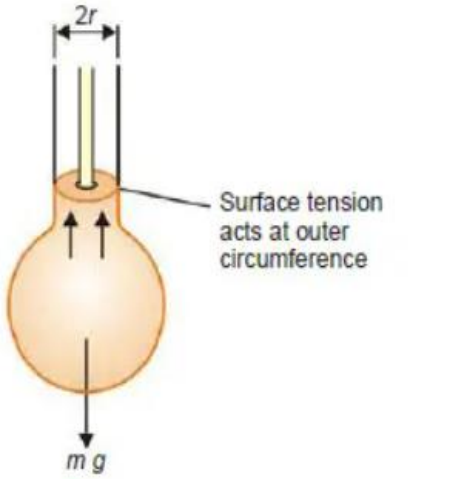


Figure 2
A drop forming from a tube of radius *r*.

$$\gamma \text{ of oil} = \frac{\text{No. of drops of water}}{\text{No of drops of oil}} \times \text{Sp.Gravity of oil}$$

Measurement of Surface Tension

2. Capillary Rise Method

- The surface tension of a liquid may be determined by the **height** to which a solution rises in a capillary that the liquid wets, usually the **glass capillary**. The surface tension is then calculated.

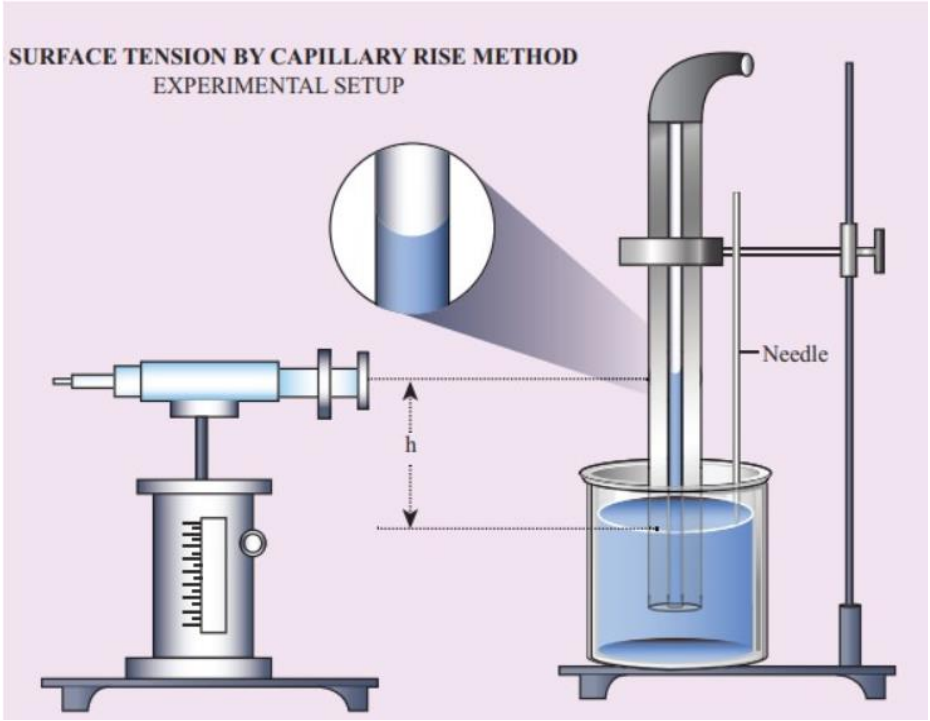
$$\gamma = \tfrac{1}{2}\, hdgr.$$

h = height to which liquid rises in capillary.

d= density of the liquid

g= acceleration due to gravity

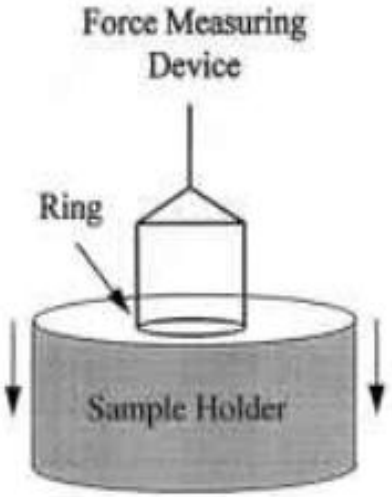
r = capillary radius

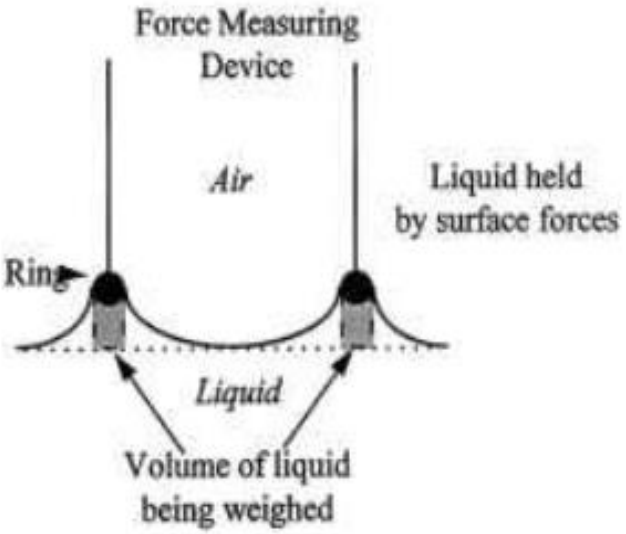


Measurement of Surface Tension

3. Du Nouy's Torsion Balance Method

- In this method a **Platinum Loop** (ring) is dipped into the liquid and **Force** in dynes required to **Separate The Loop From Surface** is measured, this instrument gives the **Direct Reading** of the surface tension on a calibrated scale.





Factors Affecting Surface Tension

- Surface Tension **Decreases** with increase of **Temperature.**

- Most **Salts** **Increase** surface tension. The increase being almost proportional to concentration, **Bile Salts Are Exception Which Lower The Surface Tension**.

- **Alkalies** increase surface tension but **Ammonia** lowers it as do the strong mineral acids.

- **Organic Substances** dissolved in a liquid usually lower surface tension.

Gibbs Thomson Principle in Relation to Surface Tension

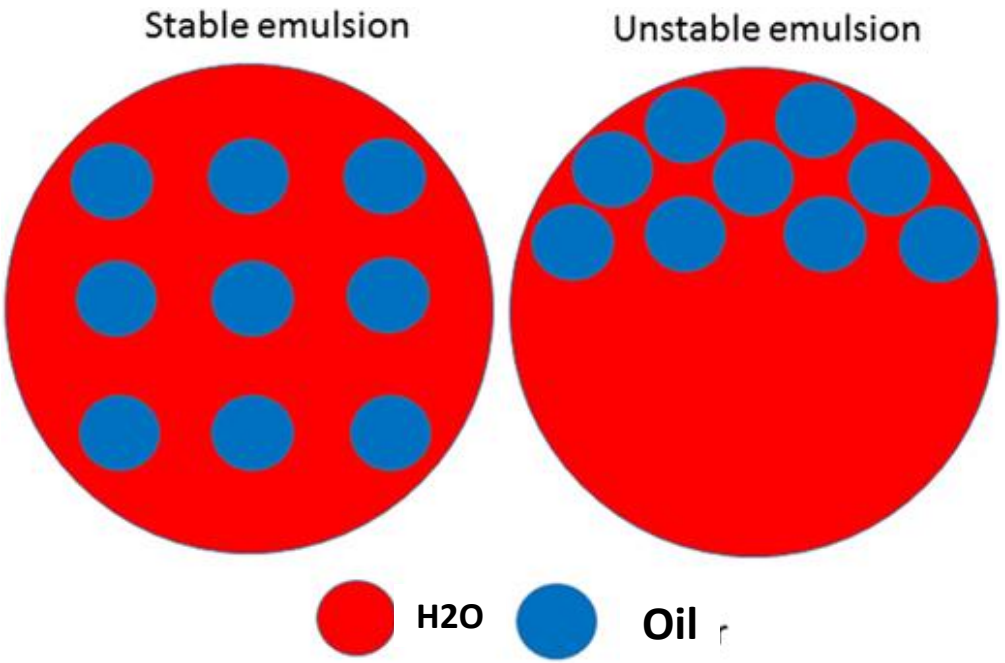
This principle determines the **Effect Of Substances** upon surface tension as follows.

- The substances that **Lower** the surface tension become concentrated in the **Surface Layer**
- Substances that **Increase** the surface tension are more concentrated within the **Interior** of the liquid than in the surface.

Emulsions and Emulsifying Agents

- If an **Oil** is shaken vigorously with **Water** it is broken down into smaller droplets to form an **Unstable Emulsion**. The droplets of oil coalesce and separate as a layer of oil on water quickly after.

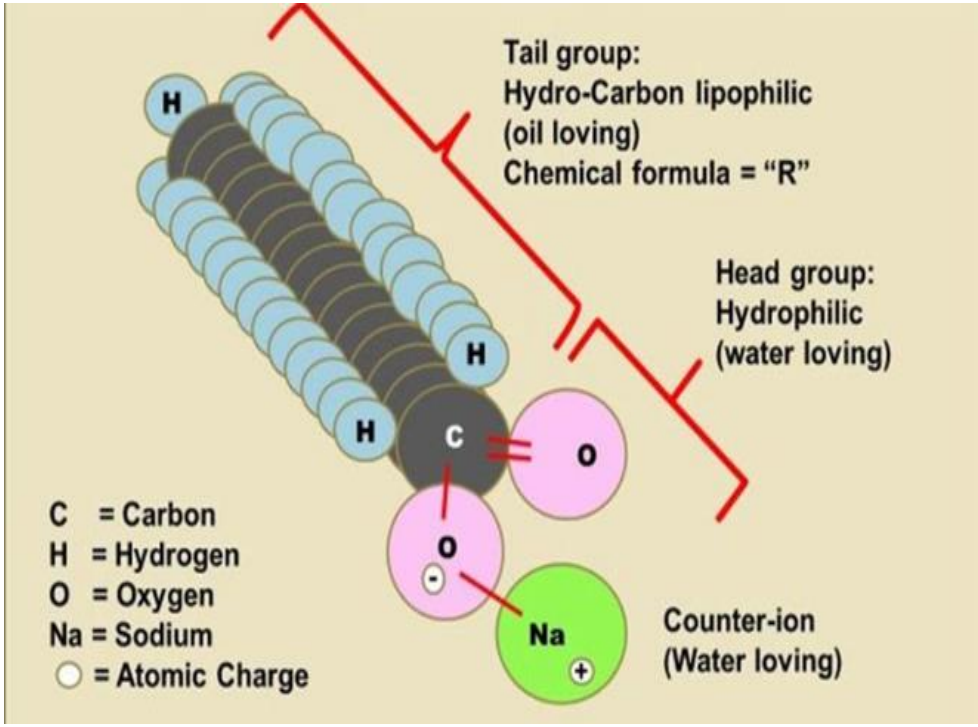
- If a little **Soap** like sodium stearate ($C_{17}H_{35}$ COONa) is added to this and then shaken again a **Stable Emulsion** is formed.



Emulsification

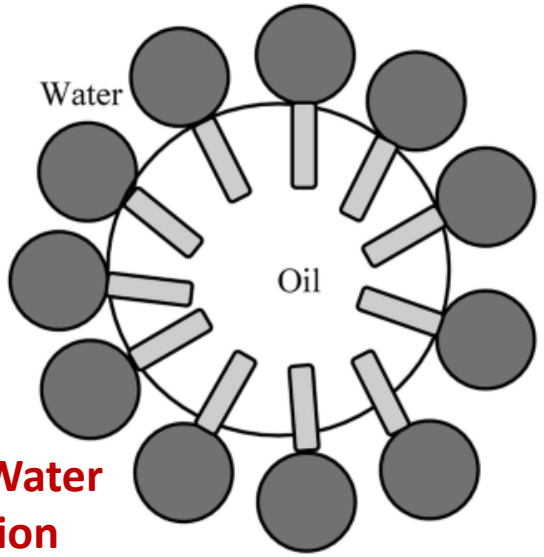
- The **Ionized soap** molecules contain two different radicals, a **Hydrocarbon radical** $C_{17}H_{35}$ that is **Lipophilic** & a **Carboxyl group** COO^- which is **Hydrophillic**, so the soap ions are oriented at the interface of oil and water with hydrocarbon radicals in oil and carboxyl ions in water.
- The negative carboxyl groups give the emulsion droplets a negative surface charge which is **balanced by Na^+ ions**.
- Surface of droplets become attracted by water due to carboxyl groups which are strongly hydrophilic.
- The soap thus **Stabilizes an Oil Emulsion** both by imparting a charge to the droplets and by making the droplets hydrophilic.

Molecular Orientation is Dependent on Emulsification



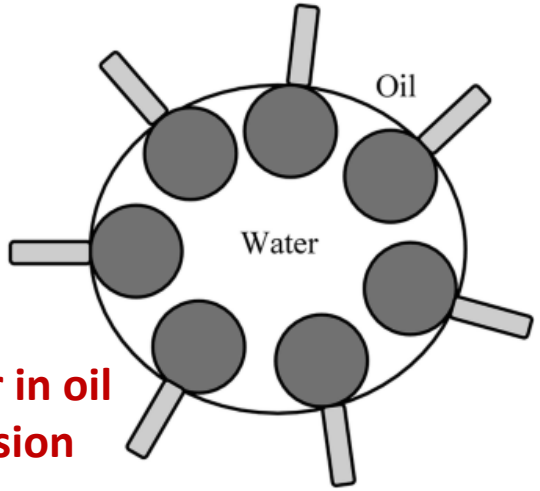
Oil In Water & Water in Oil Emulsions

- An **Oil In Water Emulsion** is stabilized by **Sodium** or **Potassium Soaps**, the **Carboxyl Ion** with its associated metal is oriented towards the **Water** while the **Hydrocarbon Radical** towards the **Oil** droplet



Oil in Water Emulsion

- **Water In Oil Emulsion** is stabilized by **Calcium Soap** the **Carboxyl** and metal ions are oriented towards the **Water** droplet and the **Hydrocarbon** radicals towards the **Oil** medium.

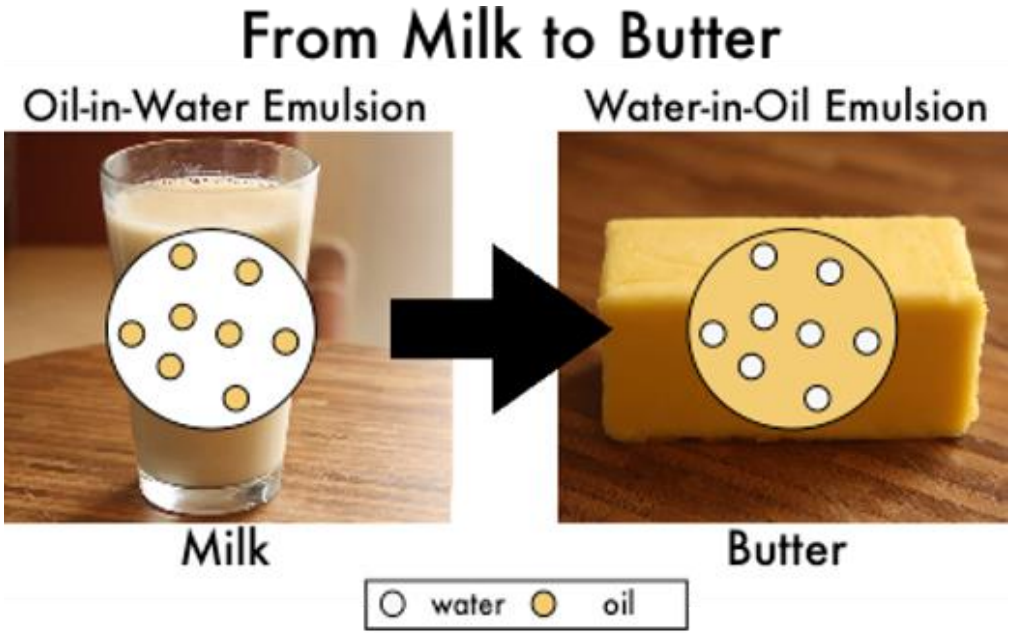


Water in oil Emulsion

Emulsification

- Various substances like high molecular weight alkyl sulfonic acids or their salts commonly called **Detergents**, **Phospholipids** and **Bile Salts** act as **Emulsifying Agents** by a similar mechanism.

- **Milk** is a naturally occurring stable emulsion of **Butter Fat in Water** with **Casein** acting as emulsifying agent.



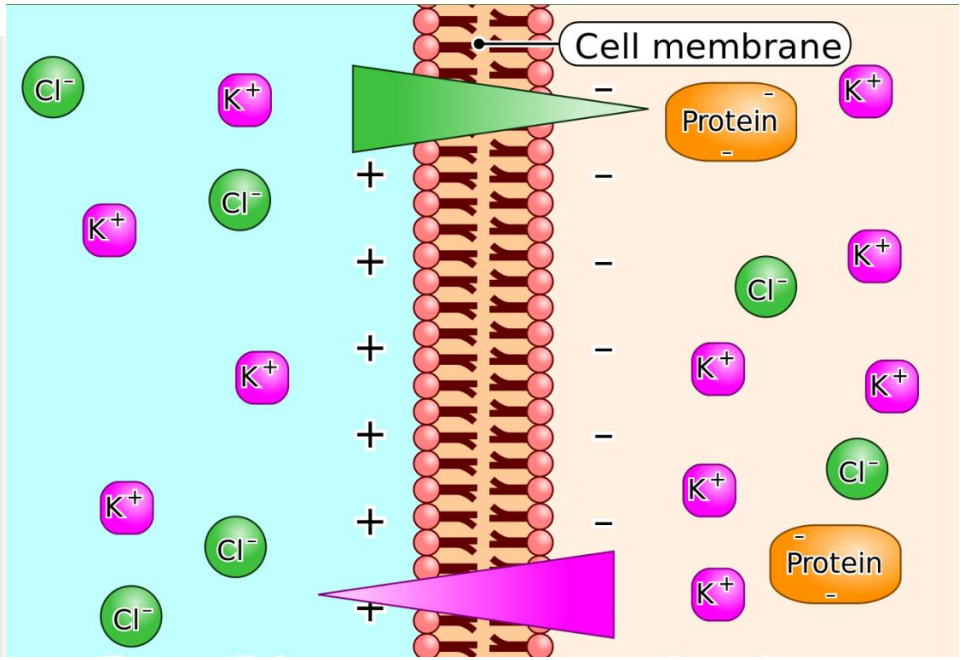
Donnan's Equilibrium

- When a membrane is **Freely Permeable** to ions, (e.g Na+, Cl-) and if the concentration of ions on both the sides is different, the ions **Freely Diffuse To Attain Equal Concentration**.

- Gibbs-Donnan observed that the presence of a **Non-diffusible Ion on One Side of the Membrane Alters the Diffusion of Diffusible Ions**.

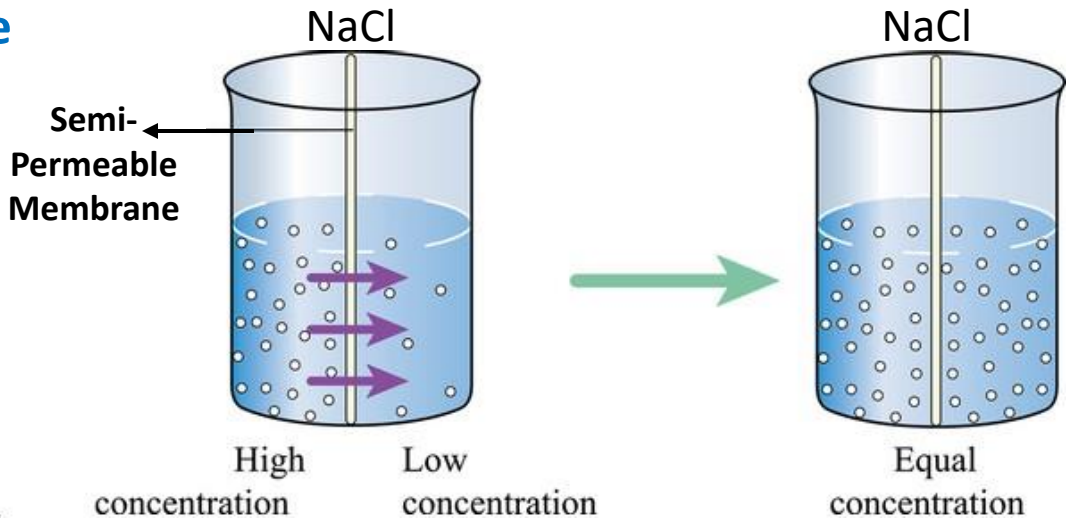
Donnan's Equilibrium

The Gibbs–**Donnan** effect (also known as the **Donnan's** effect, **Donnan** law, **Donnan equilibrium**, or Gibbs–**Donnan equilibrium**) is a name for the behaviour of charged particles near a semi-permeable **membrane** that sometimes fail to distribute evenly across the two sides of the **membrane**.



Donnan's Equilibrium

- If a **Non-Diffusible Substance** is present on any side of the semi-permeable membrane, it will **Disturb The Distribution Of Diffusible Substance** on both sides of the membrane.
- If two compartments are separated by a **Semi-permeable Membrane** that **Permits The Passage Of Water, Electrolytes And Crystalloids, But Not Of Colloids**.



- If **Different Strength Of NaCl** +**Water** are placed on both sides, the NaCl will pass through the semi-permeable membrane towards low concentration of NaCl.
- After some time, NaCl will become **Equal** in both sides. Both the compartments will have the same number of Na+ and Cl- ions (**Solute Particles**) & will exert same **Osmotic Pressure**
- The product of Na+ and Cl- of both the compartments will also be the same e.g 60 x 60 of one compartment = 60 x 60 of the second compartment.

Donnan's Equilibrium

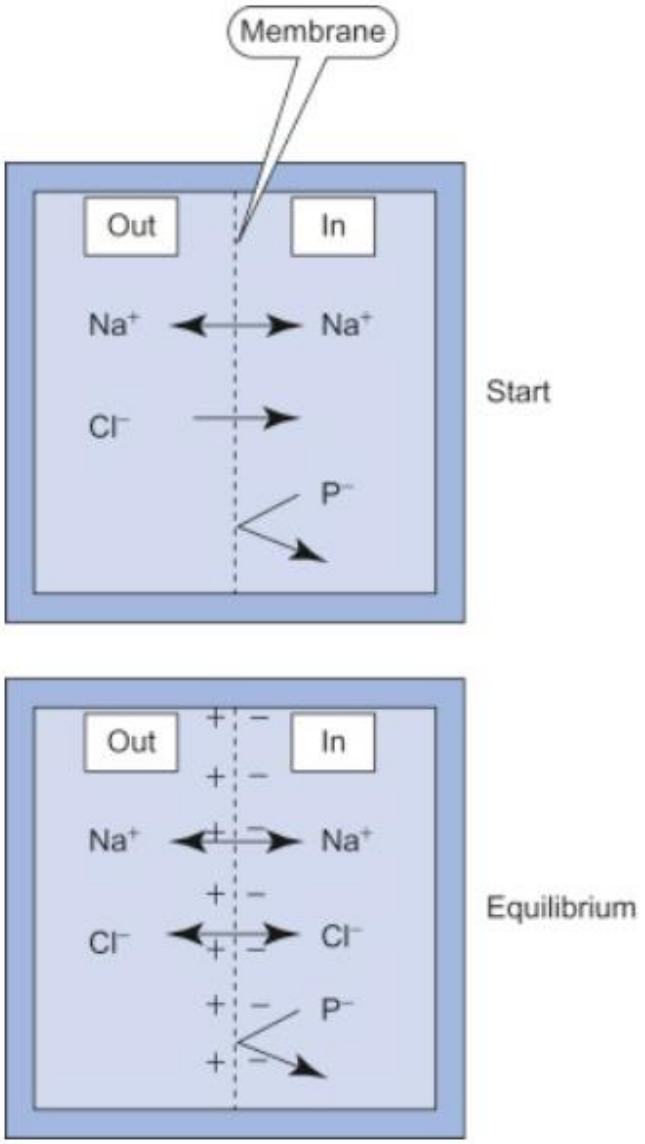
- Now according to Donnan's equilibrium :

- If we add on one side (side 1) the **Na+ Salt of a Colloid**, and **NaCl** on the other side (side2), the distribution of Na+ and Cl- ions will not remain equal in both the compartments.

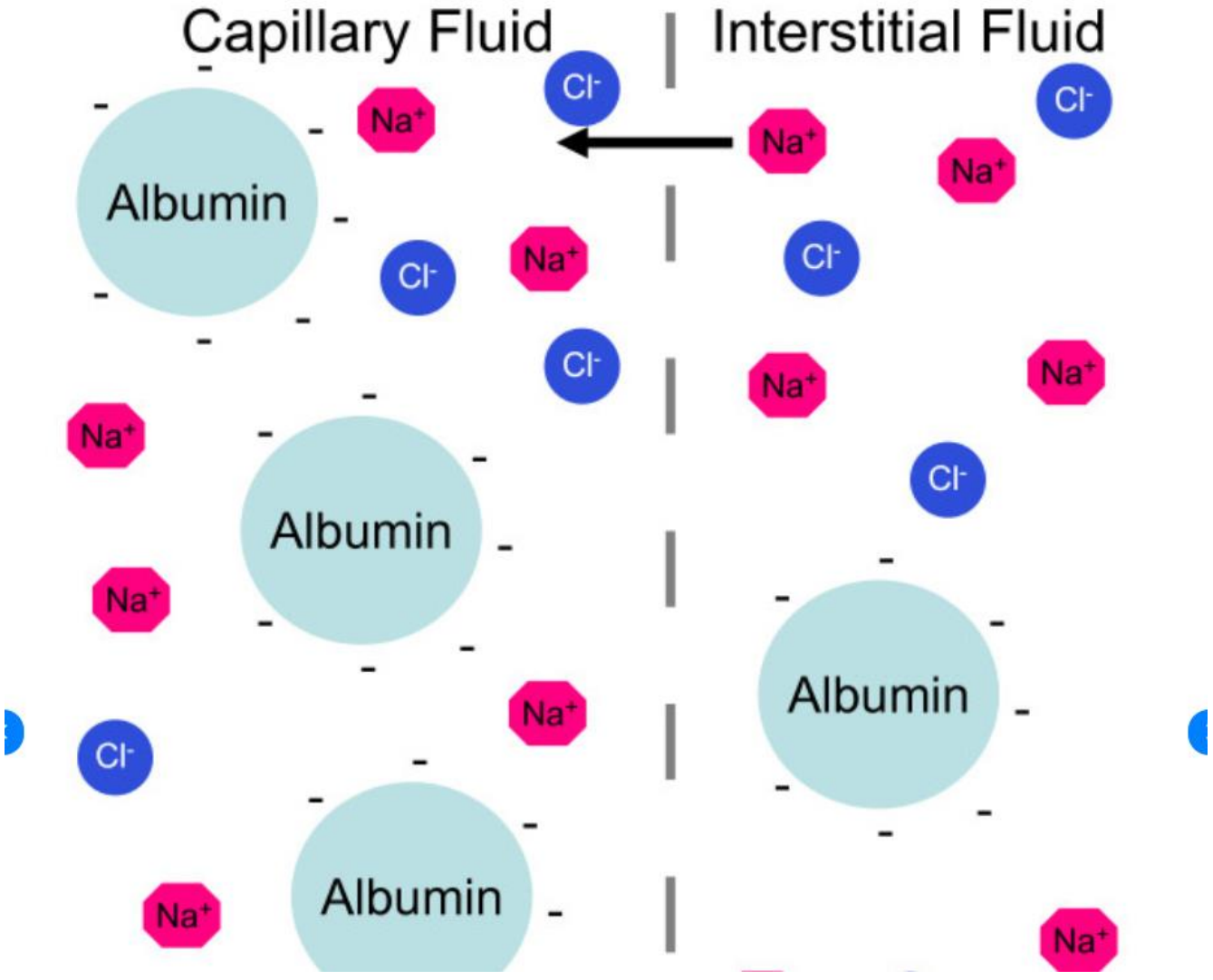
- The **Number Of Na+ Particles** in side -1 will be more than in side-2 and therefore the **Osmotic Pressure** exerted by the side-1 will also be more than side-2.

- But the **Product (Na+ X Cl-) will be equal** in both the sides e.g

  80 x 20 of side-1 = 40 x 40 of side-2



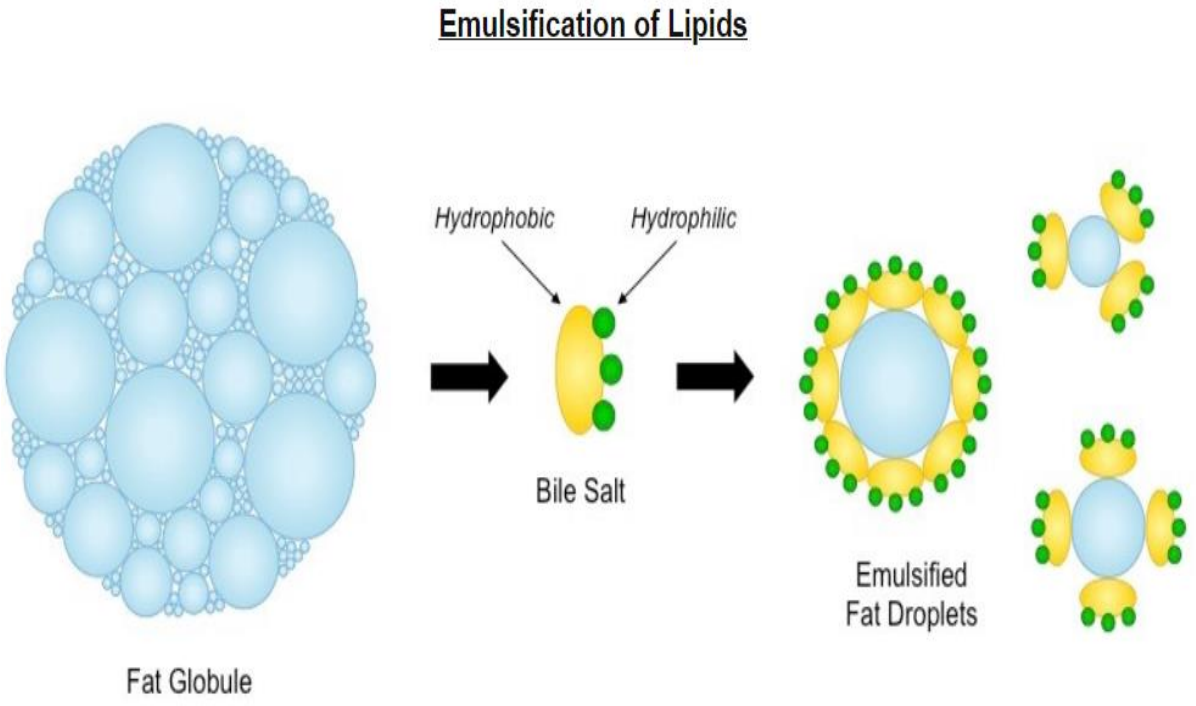
Donnan's Equilibrium



Applications of Surface Tension

Digestion and Absorption of fat

- **Bile Salts** reduce the surface tension.
- Cause **Emulsification of Fat**, thus allowing the formation of **minute particles** for effective Digestion and Absorption.
- As a result **Surface Area** is increased which favours **Lipase Activity** on lipids.



Applications of Surface Tension

- **Hay's Sulphur Test** A common lab test used for the detection of **Bile Salts in Urine of Jaundice Patients**.
- In **Normal Urine** Sulphur powder **Floats**.
- Sulphur powder when sprinkled on the surface of **Urine Containing Bile Salts**, **Sinks**.
- **Principle** is that **Bile Salts In Urine Lower The Surface Tension** which causes the Sulphur to sink.

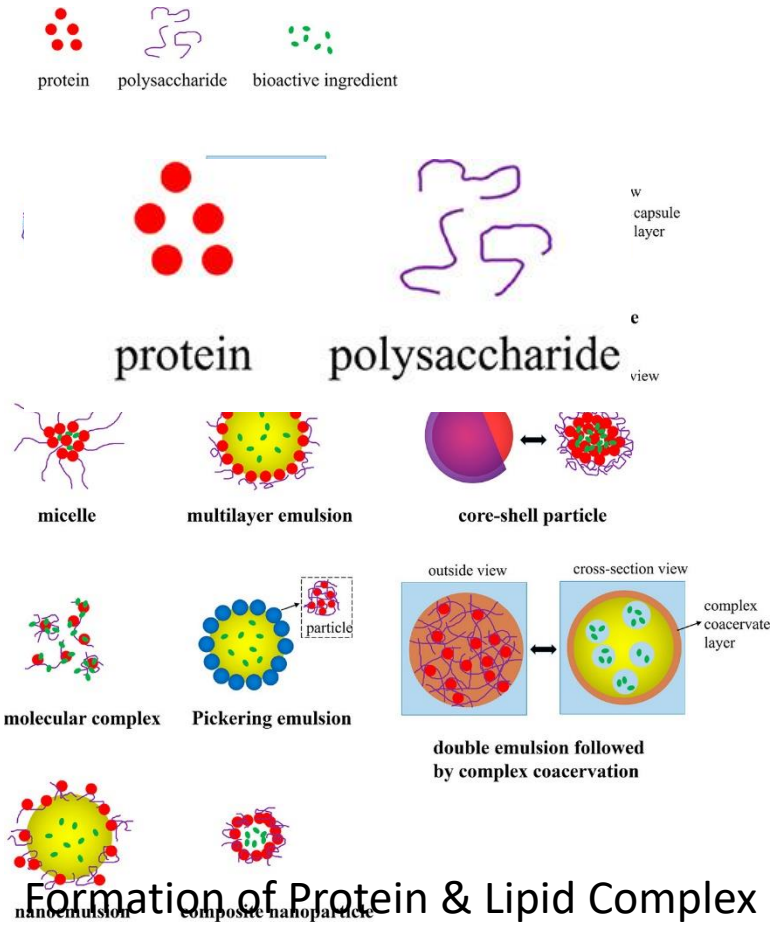
Sulphur Test for Bile Salts

Water as a Control | **Bile Salt Negative** | **Bile Salt Positive**

Applications of Surface Tension

Surface Tension and Adsorption:

- Adsorption is also a surface phenomena & is therefore related to surface tension.
- Due to the **Coupled Action** of these two processes, **Formation of Complexes of Proteins and Lipids** occurs in the biological systems.

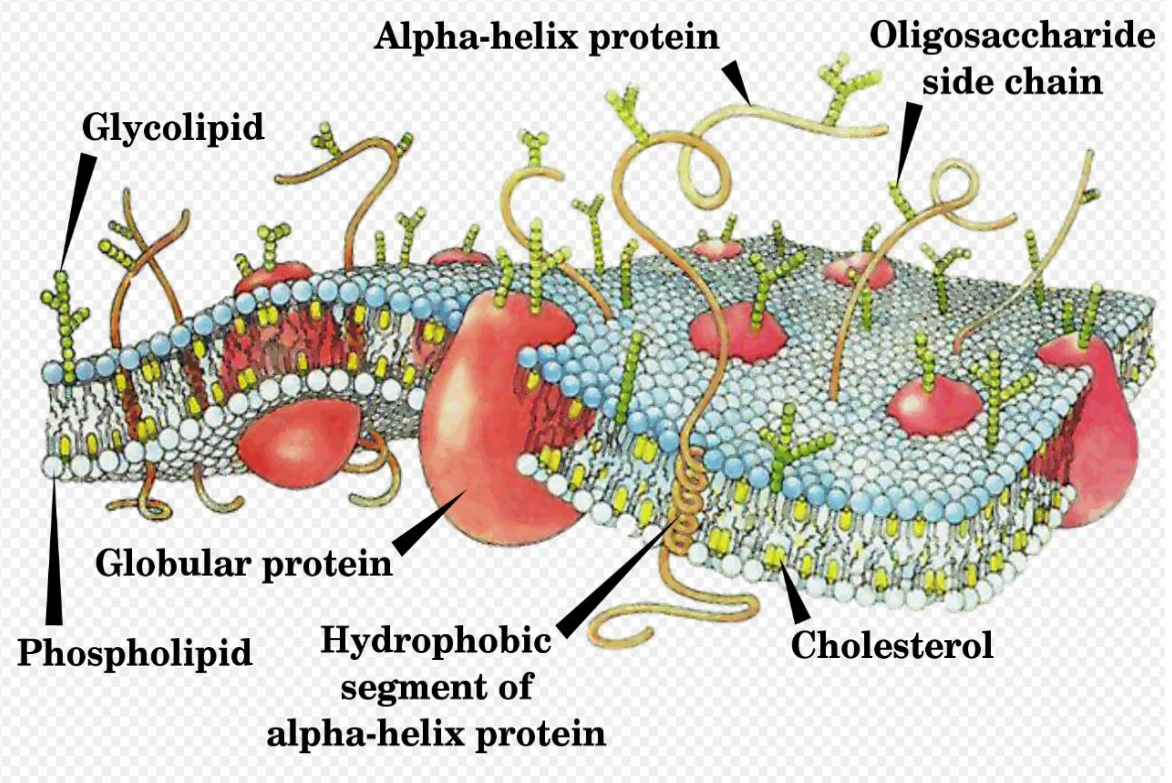


Formation of Protein & Lipid Complex

Applications of Surface Tension

Lipoprotein complex membranes

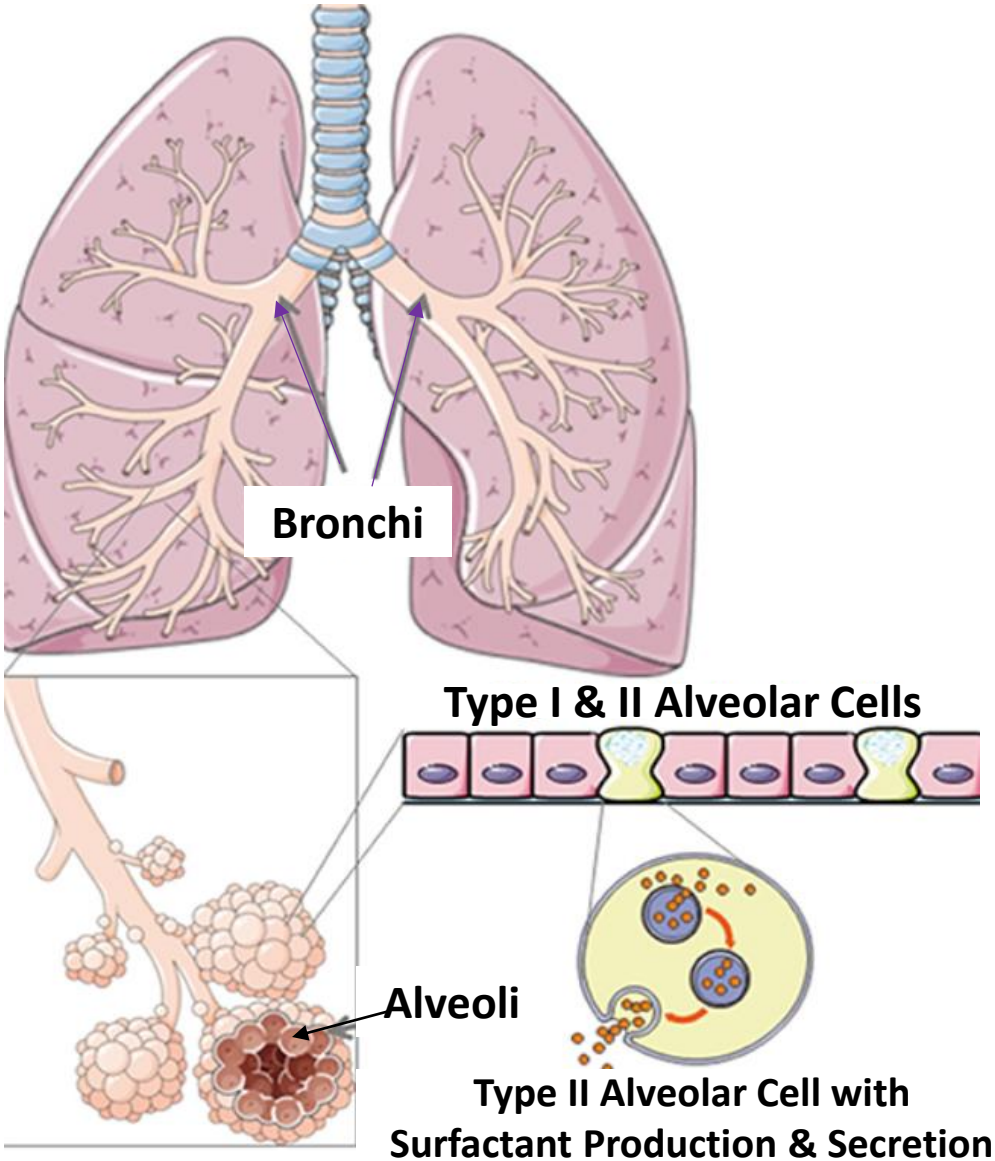
- The structure of **Plasma Membrane** is composed of **Surface Tension Reducing Substances**, namely **Lipids** and **Proteins**.
- This phenomena facilitates absorption of various compounds.



Physiological aspects of Surface Tension

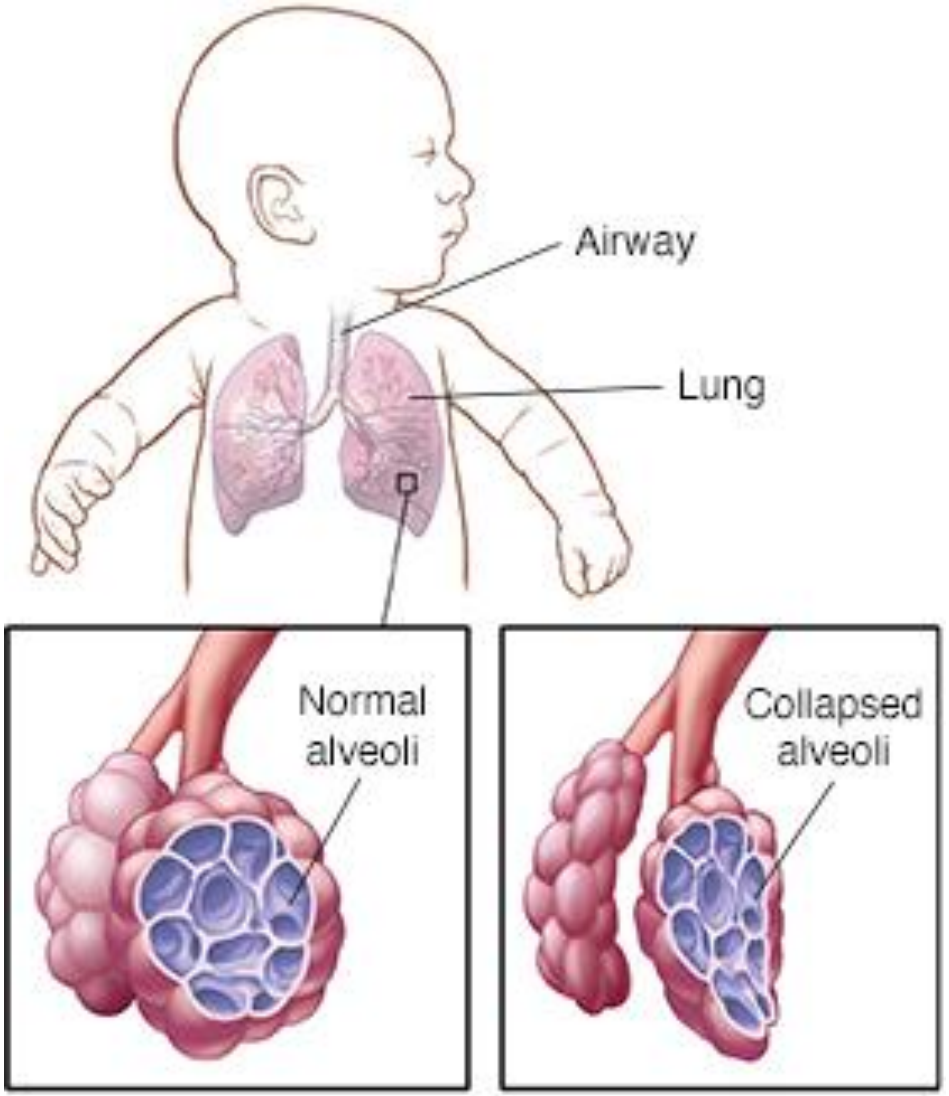
Surfactants and Lung Function:

- **Low Surface Tension** of **Alveoli** keeps them apart allowing **efficient exchange of gases** in lungs.
- Certain **Surfactants** like **Dipalmitoyl Phosphatidyl Choline** (**Dipalmitoyl Lecithin**) are responsible for maintaining **low surface tension** in the **Alveoli**.
- **Surfactant deficiency** causes "**Neonatal Respiratory Distress Syndrome - RDS**"



Neonatal Respiratory Distress Syndrome

- **Surfactant deficiency** in newborn causes "**Neonatal Respiratory Distress Syndrome - RDS**"
- Characterized by **Breathing Difficulty**
- **Deficient** production of **Surfactant** leads to **Inadequate Lung Expansion** → difficulty in exchange of gases (CO2 & O2)
- Common in **Premature** neonates
- Diagnosed by **Radiographic** findings & **Blood Tests**
- May cause Sepsis, Cerebral Palsy
- **Hyaline membrane Disease** – Previous name



Management of Neonatal RDS

Family Medicine plays important role in **Neonatal RDS** as follows:

➢ **Risk Factors** – In addition to **Prematurity** other risk factors include:

- Siblings that had RDS, Twin or multiple births, C-section (cesarean) Delivery, Diabetic Mother, Infection/Sick baby at time of delivery & Cold/stress/hypothermia at birth.

➢ **Education, Dietary Guidance & Monitoring**

- Regular antenatal checkup & administration of **Corticosteroids** if required,
- Patient Counselling about risk factors during pregnancy & recommendation of healthy diet to **Prevent Premature Birth** of fetus

➢ **Refer to Specialists – NICU**

- Basic support at **NICU** including **Thermal Regulation**, **Parentral Nutrition** & **Medications** (antibiotics) is required
- **Oxygen** administration (heated and humidified) – O_2 Saturation- 90-95%
- **Surfactant Replacement Therapy** (Exogenous Surfactant administration) through ET Tube directly into Trachea

Ethical Considerations

- **Appropriate Use of Corticosteroids** in high risk (for RDS) antenatal patients to prevent premature birth (Non-maleficence)
- **Criteria for diagnosis** must be met before Treatment of RDS is carried out (Non-maleficence)
- **Conveyance of newborn** to the Referral Centre for adequate treatment & mechanical ventilation (Justice)
- **Prevention of Disability - Oxygen Saturation Targeting** – maintaining it at 90-95% (Beneficence)

Role of AI in Management of Neonatal RDS

Artificial Intelligence plays role in Neonatal RDS in following aspects:

Identify High/Low Risk Patients

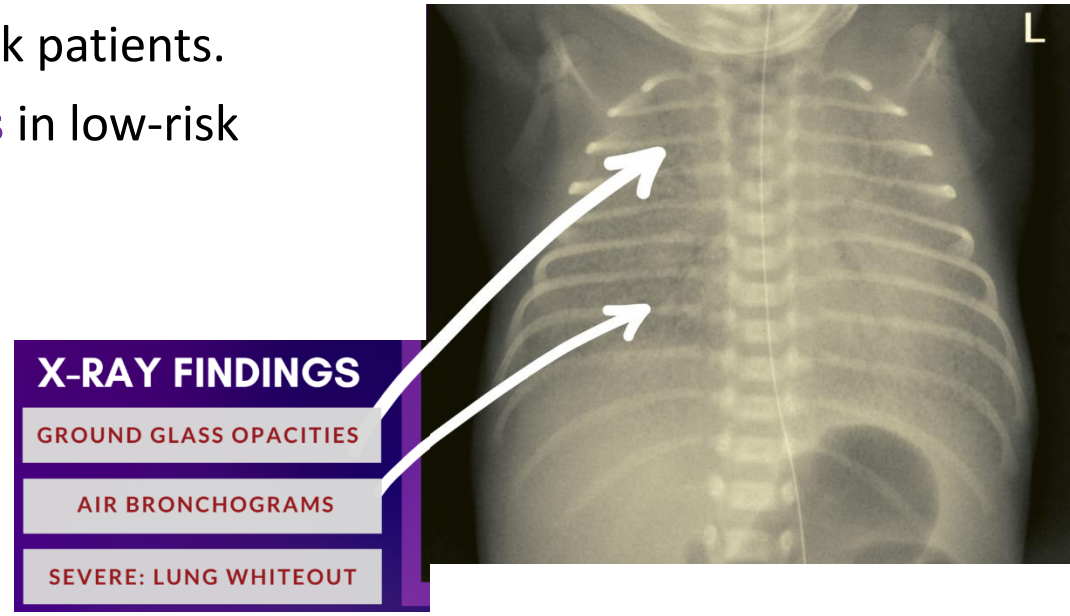
- Allocate more **resources** to high-risk patients.
- Prevent **unnecessary interventions** in low-risk patients

Data Analysis

- Data is gathered and analysed with help of AI to understand **gaps in patient care**

Diagnostic Tools

- Diagnosis of RDS by Radiological/Medical Imaging – **Highly Improved Diagnostic Accuracy**



Suggested Research Article

Link:
https://www.researchgate.net/publication/368680011_Failure_of_early_non-invasive_ventilation_in_preterm_infants_with_respiratory_distress_syndrome_in_current_care_practice_in_Spanish_level-III_neonatal_intensive_care_units_-_a_prospective_observationa

Journal Name: Frontiers in Paediatrics, Feb 2023

Title: Failure of early non-invasive ventilation in preterm infants with respiratory distress syndrome in current care practice in Spanish level-III neonatal intensive care units – a prospective observational study

Author Name:

Hector Boix, Christina Fernandes, Maria Del Mar Serrano Martin

- **Abstract**:

- Introduction: Despite advances in respiratory distress syndrome (RDS) management over the past decade, non-invasive ventilation (NIV) failure is frequent and associated with adverse outcomes. There are insufficient data on the failure of different NIV strategies currently used in clinical practice in preterm infants. Methods: This was a prospective, multicenter, observational study of very preterm infants [gestational age (GA) <32 weeks] admitted to the neonatal intensive care unit for RDS that required NIV from the first 30 min after birth. The primary outcome was the incidence of NIV failure, defined as the need for mechanical ventilation for <72 h of life. Secondary outcomes were risk factors associated with NIV failure and complication rates. Results: The study included 173 preterm infants with a median GA of 28 (IQR 27-30) weeks and a median birth weight of 1,100 (IQR 800-1,333) g. The incidence of NIV failure was 15.6%. In the multivariate analysis, lower GA (OR, 0.728; 95% CI, 0.576-0.920) independently increased the risk of NIV failure. Compared to NIV success, NIV failure was associated with higher rates of unfavorable outcomes, including pneumothorax, intraventricular hemorrhage, periventricular leukomalacia, pulmonary hemorrhage, and a combined outcome of moderate-to-severe bronchopulmonary dysplasia or death. Conclusion: NIV failure occurred in 15.6% of the preterm neonates and was associated with adverse outcomes. The use of LISA and newer NIV modalities most likely accounts for the reduced failure rate. Gestational age remains the best predictor of NIV failure and is more reliable than the fraction of inspired oxygen during the first hour of life.

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7. Journals and Researches will appear
8. You can find a Journal by clicking on JOURNALS AND DATABASE and enter a keyword to search for your desired journal.

Learning Resources

- Lippincott Illustrated Reviews – Biochemistry – Eighth Edition, chap- 17, pages – 226-227

- Essentials of Medical Biochemistry by Mushtaq Ahmed. Ninth edition, Vol 1, chapter 2, pages 50, 52, 54.
- Harper's Illustrated Biochemistry 32nd Edition
- Google Scholar
- Google Images


Thank You!